

MISSOURI RIVER
VERIFICATION OF SEDIMENT
TRANSPORT FUNCTIONS
— MISSOURI RIVER —

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CHAPTER I

INTRODUCTION

An effort is currently underway to numerically model the channel response for the 140 miles stretch of the Missouri River between Gavins Point dam and the mouth of the Platte River. This reach is degrading since the cutoff of sediment inflow by the closure of Gavins Point dam in 1953. The mechanics of response of alluvial channels to changes in water and sediment inflow is fairly well understood at present (1979) and channel response can be modelled in at least its one dimensional aspects. The accuracy of model results however depends on the quality of hydraulic resistance and sediment transport functions used in the model.

The primary objective of this study is to apply twelve sediment transport functions and methods to a selected set of data available on the Missouri and to compare their accuracy of prediction. The secondary objectives are to prepare a set of computer programs for future application of the selected function; to compile the data base so it can be used in a future data bank and to develop methods for the estimation of bed load through the analysis of sequential bed profiles. The functions selected for analysis are:

Modified Einstein Procedure (1955)

Einstein's Bed Load Function (1950)

Mahmood's Transport Function (1971)

Toffaletti's Method (1969)

Colby's Relations (1964)
Modified Colby Relations (1979)
Meyer-Peter Müller's Formula (1948)
Engelund-Hansen Formula (1967)
Acker-White Function (1973)
Yang's Unit Stream Power Relation (1973)
Laursen's Function (1958)
Shen-Hwang Method (1979)

All of these methods use the channel bed material size and the hydraulic data as inputs. Only the Modified Einstein Procedure is an exception. It uses suspended load measured up to a small distance from the bed as an additional input.

Prediction of bed material load in sand bed channel flow is notoriously inadequate. In field data collection sedimentation quantities have to be separately sampled and measured. Measurements involve collection and transportation of large volumes and numbers of samples to laboratories and methods of quantitative analysis are slow and cumbersome. Sediment transport in natural channels is highly variable in space and time, so that accuracy of measurement depends on exposure time and density of sampling. The current practice (1979) in sedimentation measurements is a compromise between the demands of accuracy and need to cover a wide range of variables. In view of this situation, it is only realistic to expect substantial levels of noise in sedimentation data.

The functions selected for study are all based on proper understanding of sediment transport phenomenon but vary in theoretical content of their formulation. Some model the mechanics of transport a great deal whereas

others are based on dimensional reasoning. The best example of the theoretical functions is Einstein's bed load function while Colby and Ackers-White are based on dimensional reasoning.

The transport of sediment is sensitive to grain size. In graded sand beds it is difficult to represent the transport behavior by a single size. Seven of the methods selected herein divide bed material into a number of size fractions and compute the load for each fraction. These functions thus yield the bed material load as well as its particle size distribution. The remaining five methods use a representative bed material size and do not compute the particle size distribution of the load.

The bed load in large sand bed channels is only a small fraction of the bed material load. However, it plays a more direct role in the bed deformation processes than the rest of sediment load. Meyer-Peter Müller's method is for prediction of bed load only. Five other functions also predict bed load separately. However, it is presently (1979) not possible to directly measure bed load in sand bed channels. So data for verification of bed load are not available. One method to indirectly measure the bed load is through the measurement of size and migration rate of bed forms. Theoretical justifications for this method exist [24,25] and with the use of sonic sounders, acquisition of relevant data is easy and relatively inexpensive. Thirteen sequential runs have been made in the Missouri, between I-480 and USPR bridges near Omaha to attempt an estimation of bed load.

This report is organized in six chapters. The preparation and reduction of data base is described in Chapter II. Chapter III presents

main features of the functions selected for analysis and describes the range of variables on which they are based. Chapter IV describes the analysis of Point-integrated data and Chapter V outlines the theory, method and results for the analysis of sequential profiles. The results obtained from the analyses are discussed in Chapter VI and the main conclusions are outlined.

This report is also accompanied by seven appendices as follows:

- Appendix I Data Listings
- Appendix II Program Listings
- Appendix III Bed Material Computations for Category A (DI) Data
 - Part A: Modified Einstein Procedure
 - Part B: Einstein Bed Load Function
 - Part C: Mahmood Transport Function
 - Part D: Toffaleti's Formula
 - Part E: Original and Modified Colby Relations
 - Part F: Five Functions:
 - Meyer-Peter Müller
 - Engelund-Hansen
 - Ackers-White
 - Yang's Minimum Stream Power
 - Laursen
 - Part G: Shen-Hwang Method

Appendix IV Analysis of Category B (PI-DI) Data

Part A: Runs AAA through AAF

Part B: Runs AAG AAL

Part C: Runs AAM AAQ

Part D: Runs AAR AAV

Appendix V Analysis of Category C (PI) Data

Appendix VI Analysis of Sequential Profiles

Appendix VII Summary Tables and Plots.

The appendices are voluminous and are not included in the body of this report. They can be made available on request, however, for research purposes.